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Engineering AG
**Zeughausstrasse 43, 8004 Zurich, Switzerland**

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**Accreditation No.: SCS 108**

**Client** Sporton (Auden)

**Certificate No: ET3-1788_Sep04**

# CALIBRATION CERTIFICATE

| | |
|---|---|
| Object | ET3DV6 - SN:1788 |
| Calibration procedure(s) | QA CAL-01.v5<br>Calibration procedure for dosimetric E-field probes |
| Calibration date: | September 30, 2004 |
| Condition of the calibrated item | In Tolerance |

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards | ID # | Cal Date (Calibrated by, Certificate No.) | Scheduled Calibration |
|---|---|---|---|
| Power meter E4419B | GB41293874 | 5-May-04 (METAS, No. 251-00388) | May-05 |
| Power sensor E4412A | MY41495277 | 5-May-04 (METAS, No. 251-00388) | May-05 |
| Reference 3 dB Attenuator | SN: S5054 (3c) | 3-Apr-03 (METAS, No. 251-00403) | Aug-05 |
| Reference 20 dB Attenuator | SN: S5086 (20b) | 3-May-04 (METAS, No. 251-00389) | May-05 |
| Reference 30 dB Attenuator | SN: S5129 (30b) | 3-Apr-03 (METAS, No. 251-00404) | Aug-05 |
| Reference Probe ES3DV2 | SN:3013 | 8-Jan-04 (SPEAG, No. ES3-3013_Jan04) | Jan-05 |
| DAE4 | SN: 617 | 26-May-04 (SPEAG, No. DAE4-617_May04) | May-05 |

| Secondary Standards | ID # | Check Date (in house) | Scheduled Check |
|---|---|---|---|
| Power sensor HP 8481A | MY41092180 | 18-Sep-02 (SPEAG, in house check Oct-03) | In house check: Oct 05 |
| RF generator HP 8648C | US3642U01700 | 4 Aug 99 (SPEAG, in house check Dec-03) | In house check: Dec-05 |
| Network Analyzer HP 8753E | US37390585 | 18-Oct-01 (SPEAG, in house check Nov-03) | In house check: Nov 04 |

| | Name | Function | Signature |
|---|---|---|---|
| Calibrated by: | Nico Vetterli | Laboratory Technician | |
| Approved by: | Katja Pokovic | Technical Manager | |

Issued: October 1, 2004

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**Glossary:**

| | |
|---|---|
| TSL | tissue simulating liquid |
| NORMx,y,z | sensitivity in free space |
| ConF | sensitivity in TSL / NORMx,y,z |
| DCP | diode compression point |
| Polarization φ | φ rotation around probe axis |
| Polarization ϑ | ϑ rotation around an axis that is in the plane normal to probe axis (at measurement center), i.e., ϑ = 0 is normal to probe axis |

**Calibration is Performed According to the Following Standards:**

a) IEEE Std 1528-2003, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", December 2003
b) CENELEC EN 50361, "Basic standard for the measurement of Specific Absorption Rate related to human exposure to electromagnetic fields from mobile phones (300 MHz - 3 GHz), July 2001

**Methods Applied and Interpretation of Parameters:**

- *NORMx,y,z:* Assessed for E-field polarization ϑ = 0 (f ≤ 900 MHz in TEM-cell; f > 1800 MHz: R22 waveguide). NORMx,y,z are only intermediate values, i.e., the uncertainties of NORMx,y,z does not effect the $E^2$-field uncertainty inside TSL (see below *ConvF*).
- *NORM(f)x,y,z = NORMx,y,z * frequency_response* (see Frequency Response Chart). This linearization is implemented in DASY4 software versions later than 4.2. The uncertainty of the frequency response is included in the stated uncertainty of *ConvF*.
- *DCPx,y,z:* DCP are numerical linearization parameters assessed based on the data of power sweep (no uncertainty required). DCP does not depend on frequency nor media.
- *ConvF and Boundary Effect Parameters:* Assessed in flat phantom using E-field (or Temperature Transfer Standard for f ≤ 800 MHz) and inside waveguide using analytical field distributions based on power measurements for f > 800 MHz. The same setups are used for assessment of the parameters applied for boundary compensation (alpha, depth) of which typical uncertainty values are given. These parameters are used in DASY4 software to improve probe accuracy close to the boundary. The sensitivity in TSL corresponds to *NORMx,y,z * ConvF* whereby the uncertainty corresponds to that given for *ConvF*. A frequency dependent *ConvF* is used in DASY 4.3 B17 and higher which allows extending the validity from ± 50 MHz to ± 100 MHz.
- *Spherical isotropy (3D deviation from isotropy)*: in a field of low gradients realized using a flat phantom exposed by a patch antenna.
- *Sensor Offset*: The sensor offset corresponds to the offset of virtual measurement center from the probe tip (on probe axis). No tolerance required.

# Probe ET3DV6

## SN:1788

| | |
|---|---|
| Manufactured: | May 28, 2003 |
| Last calibrated: | August 29, 2003 |
| Recalibrated: | September 30, 2004 |

Calibrated for DASY Systems

(Note: non-compatible with DASY2 system!)

ET3DV6 SN:1788 September 30, 2004

# DASY - Parameters of Probe: ET3DV6 SN:1788

## Sensitivity in Free Space[A] Diode Compression[B]

| | | | | |
|---|---|---|---|---|
| NormX | 1.68 ± 9.9% | $\mu V/(V/m)^2$ | DCP X | 94 mV |
| NormY | 1.70 ± 9.9% | $\mu V/(V/m)^2$ | DCP Y | 94 mV |
| NormZ | 1.74 ± 9.9% | $\mu V/(V/m)^2$ | DCP Z | 94 mV |

## Sensitivity in Tissue Simulating Liquid (Conversion Factors)

Please see Page 8.

## Boundary Effect

**TSL 900 MHz Typical SAR gradient: 5 % per mm**

| Sensor Center to Phantom Surface Distance | | 3.7 mm | 4.7 mm |
|---|---|---|---|
| $SAR_{be}$ [%] | Without Correction Algorithm | 8.1 | 4.4 |
| $SAR_{be}$ [%] | With Correction Algorithm | 0.7 | 0.1 |

**TSL 1810 MHz Typical SAR gradient: 10 % per mm**

| Sensor Center to Phantom Surface Distance | | 3.7 mm | 4.7 mm |
|---|---|---|---|
| $SAR_{be}$ [%] | Without Correction Algorithm | 12.0 | 8.2 |
| $SAR_{be}$ [%] | With Correction Algorithm | 0.9 | 0.1 |

## Sensor Offset

| | |
|---|---|
| Probe Tip to Sensor Center | 2.7 mm |

**The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.**

[A] The uncertainties of NormX,Y,Z do not affect the $E^2$-field uncertainty inside TSL (see Page 8).

[B] Numerical linearization parameter: uncertainty not required.

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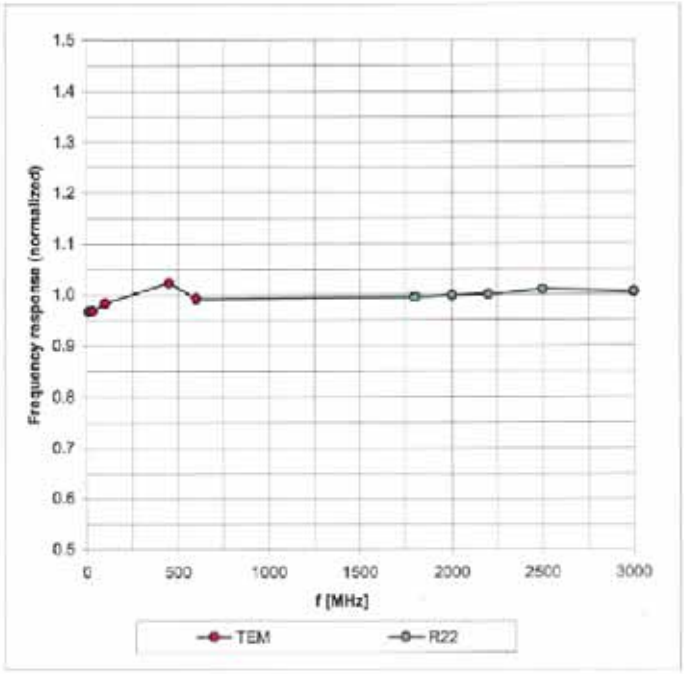
## Frequency Response of E-Field

(TEM-Cell:ifi110 EXX, Waveguide: R22)




Uncertainty of Frequency Response of E-field: ± 6.3% (k=2)

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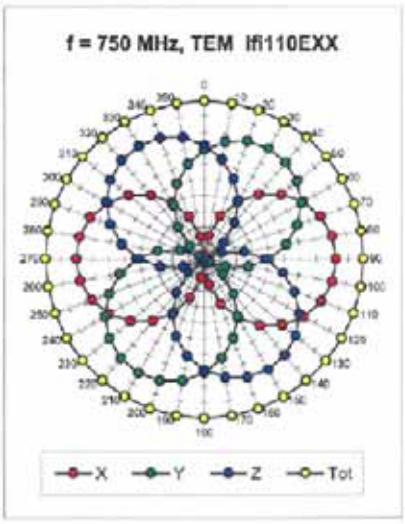
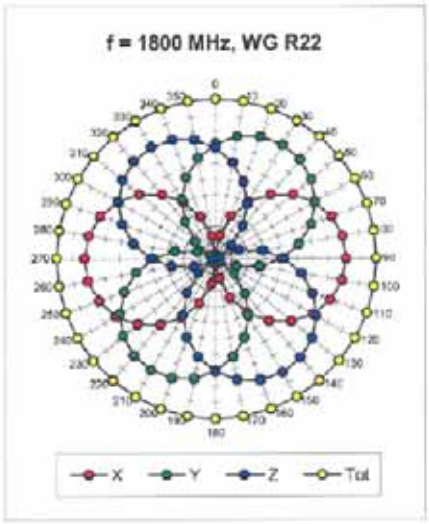
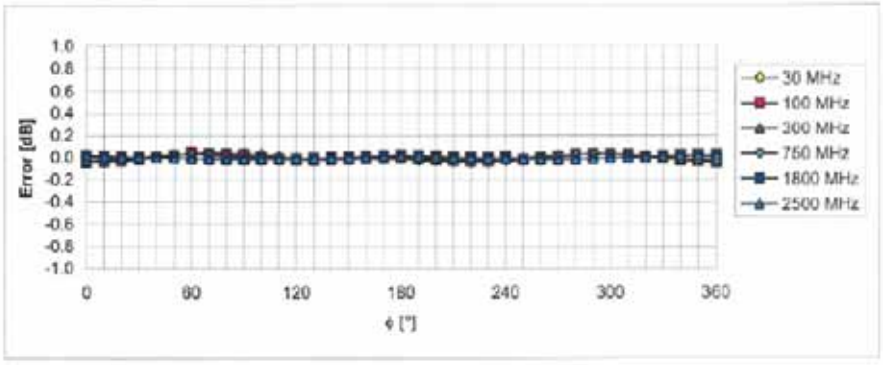
## Receiving Pattern ($\phi$), $\vartheta$ = 0°




Uncertainty of Axial Isotropy Assessment: ± 0.5% (k=2)

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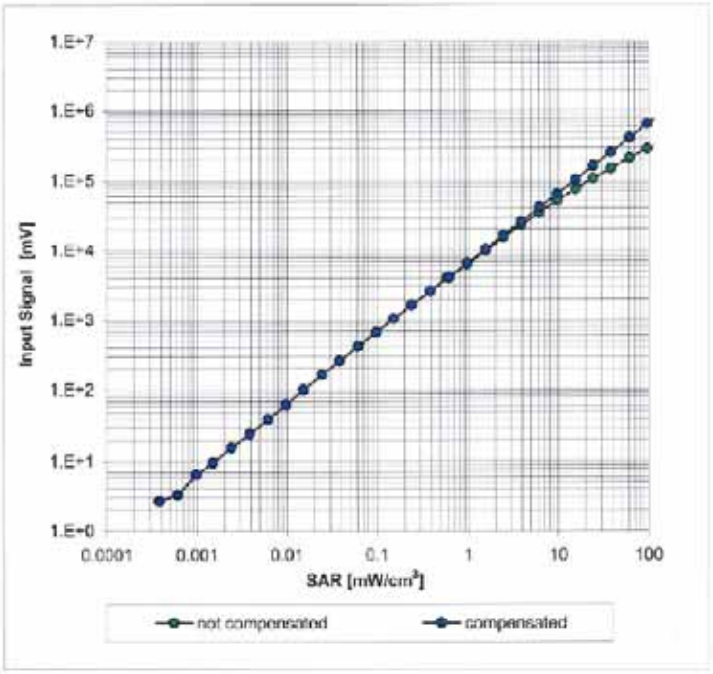
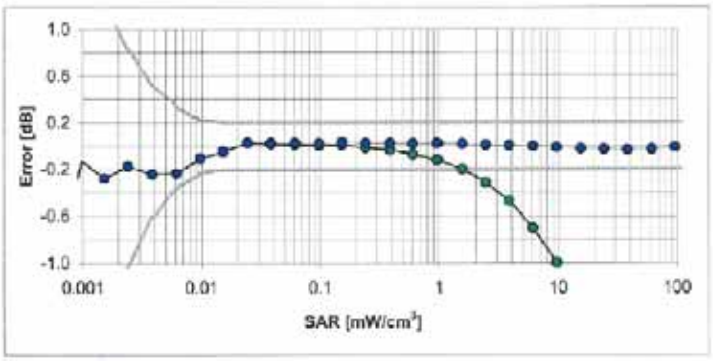
## Dynamic Range f($SAR_{head}$)

(Waveguide R22, f = 1800 MHz)




Uncertainty of Linearity Assessment: ± 0.6% (k=2)

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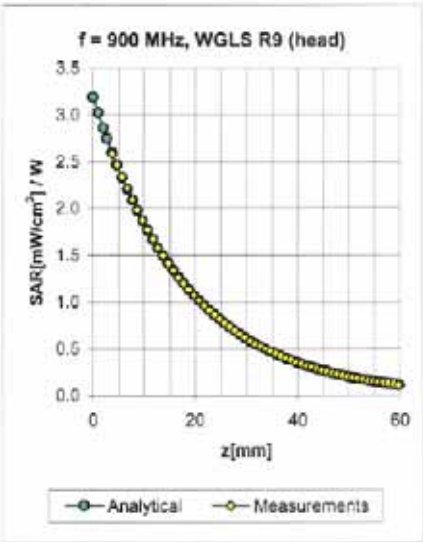
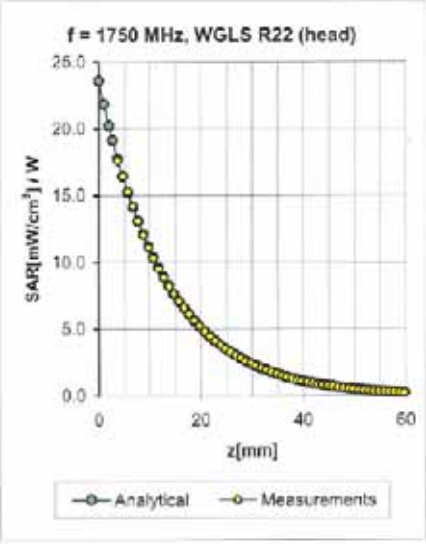
ET3DV6 SN:1788 September 30, 2004

# Conversion Factor Assessment




| f [MHz] | Validity [MHz][C] | TSL | Permittivity | Conductivity | Alpha | Depth | ConvF Uncertainty |
|---|---|---|---|---|---|---|---|
| 835 | ± 50 / ± 100 | Head | 41.5 ± 5% | 0.90 ± 5% | 1.12 | 1.42 | 6.74 ± 11.0% (k=2) |
| 900 | ± 50 / ± 100 | Head | 41.5 ± 5% | 0.97 ± 5% | 1.07 | 1.44 | 6.63 ± 11.0% (k=2) |
| 1750 | ± 50 / ± 100 | Head | 40.0 ± 5% | 1.40 ± 5% | 0.56 | 2.31 | 5.37 ± 11.0% (k=2) |
| 1900 | ± 50 / ± 100 | Head | 40.0 ± 5% | 1.40 ± 5% | 0.55 | 2.42 | 5.16 ± 11.0% (k=2) |
| 2000 | ± 50 / ± 100 | Head | 40.0 ± 5% | 1.40 ± 5% | 0.54 | 2.59 | 4.88 ± 11.0% (k=2) |
| 2450 | ± 50 / ± 100 | Head | 39.2 ± 5% | 1.80 ± 5% | 0.65 | 2.22 | 4.56 ± 11.8% (k=2) |
| | | | | | | | |
| 835 | ± 50 / ± 100 | Body | 55.2 ± 5% | 0.97 ± 5% | 1.04 | 1.52 | 6.53 ± 11.0% (k=2) |
| 900 | ± 50 / ± 100 | Body | 55.0 ± 5% | 1.05 ± 5% | 0.99 | 1.56 | 6.17 ± 11.0% (k=2) |
| 1750 | ± 50 / ± 100 | Body | 53.3 ± 5% | 1.52 ± 5% | 0.63 | 2.74 | 4.73 ± 11.0% (k=2) |
| 1900 | ± 50 / ± 100 | Body | 53.3 ± 5% | 1.52 ± 5% | 0.55 | 2.82 | 4.56 ± 11.0% (k=2) |
| 2000 | ± 50 / ± 100 | Body | 53.3 ± 5% | 1.52 ± 5% | 0.54 | 2.98 | 4.43 ± 11.0% (k=2) |
| 2450 | ± 50 / ± 100 | Body | 52.7 ± 5% | 1.95 ± 5% | 0.72 | 2.00 | 4.26 ± 11.8% (k=2) |

[C] The validity of ± 100 MHz only applies for DASY 4.3 B17 and higher (see Page 2). The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band.

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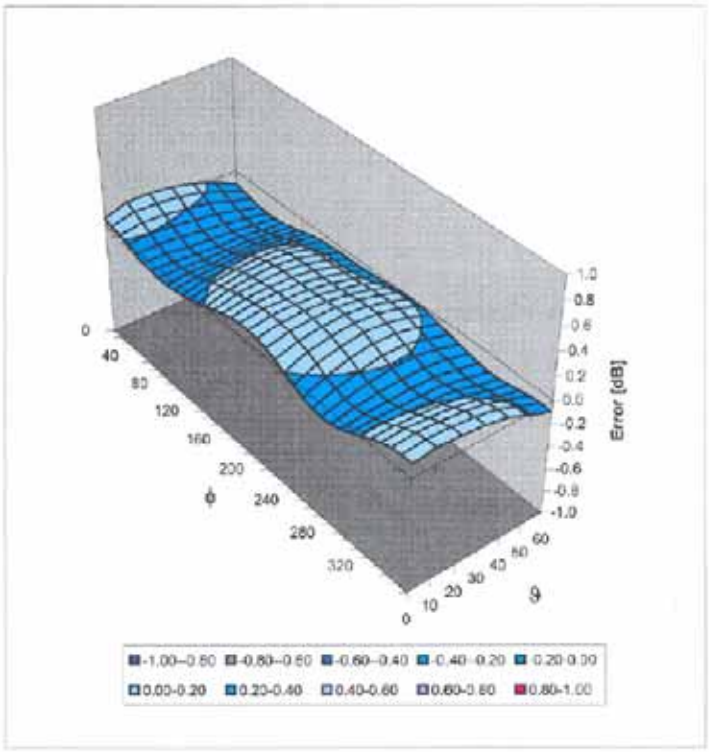
## Deviation from Isotropy in HSL

Error (ϕ, ϑ), f = 900 MHz




Uncertainty of Spherical Isotropy Assessment: ± 2.6% (k=2)

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**Accreditation No.: SCS 108**

Client **Sporton (Auden)**

**Certificate No: DAE3-577_Nov04**

# CALIBRATION CERTIFICATE

| | |
|---|---|
| Object | DAE3 - SD 000 D03 AA - SN: 577 |
| Calibration procedure(s) | QA CAL-06.v10<br>Calibration procedure for the data acquisition unit (DAE) |
| Calibration date: | November 17, 2004 |
| Condition of the calibrated item | In Tolerance |

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards | ID # | Cal Date (Calibrated by, Certificate No.) | Scheduled Calibration |
|---|---|---|---|
| Fluke Process Calibrator Type 702 | SN: 6295803 | 7-Sep-04 (Sintrel, No.E-040073) | Sep-05 |
| **Secondary Standards** | **ID #** | **Check Date (in house)** | **Scheduled Check** |
| Calibrator Box V1.1 | SE UMS 006 AB 1002 | 16-Jul-04 (SPEAG, in house check) | In house check Jul-05 |

| | Name | Function | Signature |
|---|---|---|---|
| Calibrated by: | Eric Hainfeld | Technician | |
| Approved by: | Fin Bomholt | R&D Director | i.V. |

Issued: November 17, 2004

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**Glossary**

| | |
|---|---|
| DAE | digital acquisition electronics |
| Connector angle | information used in DASY system to align probe sensor X to the robot coordinate system. |

**Methods Applied and Interpretation of Parameters**

- *DC Voltage Measurement:* Calibration Factor assessed for use in DASY system by comparison with a calibrated instrument traceable to national standards. The figure given corresponds to the full scale range of the voltmeter in the respective range.
- *Connector angle*: The angle of the connector is assessed measuring the angle mechanically by a tool inserted. Uncertainty is not required.
- The following parameters contain technical information as a result from the performance test and require no uncertainty.
- *DC Voltage Measurement Linearity:* Verification of the Linearity at +10% and -10% of the nominal calibration voltage. Influence of offset voltage is included in this measurement.
- *Common mode sensitivity:* Influence of a positive or negative common mode voltage on the differential measurement.
- *Channel separation:* Influence of a voltage on the neighbor channels not subject to an input voltage.
- *AD Converter Values with inputs shorted:* Values on the internal AD converter corresponding to zero input voltage
- *Input Offset Measurement*: Output voltage and statistical results over a large number of zero voltage measurements.
- *Input Offset Current:* Typical value for information; Maximum channel input offset current, not considering the input resistance.
- *Input resistance:* DAE input resistance at the connector, during internal auto-zeroing and during measurement.
- *Low Battery Alarm Voltage:* Typical value for information. Below this voltage, a battery alarm signal is generated.
- *Power consumption:* Typical value for information. Supply currents in various operating modes.

## DC Voltage Measurement

A/D - Converter Resolution nominal

| | | | | |
|---|---|---|---|---|
| High Range: | 1LSB = | 6.1μV , | full range = | -100...+300 mV |
| Low Range: | 1LSB = | 61nV , | full range = | -1.....+3mV |

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

| Calibration Factors | X | Y | Z |
|---|---|---|---|
| High Range | 404.437 ± 0.1% (k=2) | 403.891 ± 0.1% (k=2) | 404.359 ± 0.1% (k=2) |
| Low Range | 3.94121 ± 0.7% (k=2) | 3.89867 ± 0.7% (k=2) | 3.95408 ± 0.7% (k=2) |

## Connector Angle

| | |
|---|---|
| **Connector Angle** to be used in DASY system | 127 ° ± 1 ° |

## Appendix

### 1. DC Voltage Linearity

| High Range | | Input (μV) | Reading (μV) | Error (%) |
|---|---|---|---|---|
| Channel X | + Input | 200000 | 200000.6 | 0.00 |
| Channel X | + Input | 20000 | 20001.77 | 0.01 |
| Channel X | - Input | 20000 | -19991.81 | -0.04 |
| Channel Y | + Input | 200000 | 199999.7 | 0.00 |
| Channel Y | + Input | 20000 | 19999.20 | 0.00 |
| Channel Y | - Input | 20000 | -19994.82 | -0.03 |
| Channel Z | + Input | 200000 | 200000.2 | 0.00 |
| Channel Z | + Input | 20000 | 19996.22 | -0.02 |
| Channel Z | - Input | 20000 | -19996.74 | -0.02 |

| Low Range | | Input (μV) | Reading (μV) | Error (%) |
|---|---|---|---|---|
| Channel X | + Input | 2000 | 2000 | 0.00 |
| Channel X | + Input | 200 | 200.05 | 0.03 |
| Channel X | - Input | 200 | -200.88 | 0.44 |
| Channel Y | + Input | 2000 | 1999.9 | 0.00 |
| Channel Y | + Input | 200 | 199.73 | -0.13 |
| Channel Y | - Input | 200 | -200.53 | 0.27 |
| Channel Z | + Input | 2000 | 2000.1 | 0.00 |
| Channel Z | + Input | 200 | 199.25 | -0.38 |
| Channel Z | - Input | 200 | -201.42 | 0.71 |

### 2. Common mode sensitivity

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

| | Common mode Input Voltage (mV) | High Range Average Reading (μV) | Low Range Average Reading (μV) |
|---|---|---|---|
| Channel X | 200 | 13.15 | 12.30 |
| | - 200 | -12.61 | -12.86 |
| Channel Y | 200 | -7.43 | -7.53 |
| | - 200 | 6.30 | 6.52 |
| Channel Z | 200 | -0.16 | 0.31 |
| | - 200 | -1.51 | -1.48 |

### 3. Channel separation

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

| | Input Voltage (mV) | Channel X (μV) | Channel Y (μV) | Channel Z (μV) |
|---|---|---|---|---|
| Channel X | 200 | - | 1.90 | -0.22 |
| Channel Y | 200 | 1.47 | - | 4.60 |
| Channel Z | 200 | -1.40 | -0.08 | - |

## 4. AD-Converter Values with inputs shorted

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

| | High Range (LSB) | Low Range (LSB) |
|---|---|---|
| Channel X | 15948 | 15814 |
| Channel Y | 15960 | 16073 |
| Channel Z | 16236 | 16172 |

## 5. Input Offset Measurement

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec
Input 10MΩ

| | Average (μV) | min. Offset (μV) | max. Offset (μV) | Std. Deviation (μV) |
|---|---|---|---|---|
| Channel X | 0.03 | -3.07 | 1.24 | 0.58 |
| Channel Y | -0.66 | -2.19 | 1.96 | 0.55 |
| Channel Z | -0.91 | -2.82 | 0.42 | 0.39 |

## 6. Input Offset Current

Nominal Input circuitry offset current on all channels: <25fA

## 7. Input Resistance

| | Zeroing (MOhm) | Measuring (MOhm) |
|---|---|---|
| Channel X | 0.2000 | 199.3 |
| Channel Y | 0.2000 | 200.4 |
| Channel Z | 0.2001 | 199.5 |

## 8. Low Battery Alarm Voltage (verified during pre test)

| Typical values | Alarm Level (VDC) |
|---|---|
| Supply (+ Vcc) | +7.9 |
| Supply (- Vcc) | -7.6 |

## 9. Power Consumption (verified during pre test)

| Typical values | Switched off (mA) | Stand by (mA) | Transmitting (mA) |
|---|---|---|---|
| Supply (+ Vcc) | +0.0 | +6 | +14 |
| Supply (- Vcc) | -0.01 | -8 | -9 |

## 10. Common Mode Bit Generation (verified during pre test)

| Typical values | Bit set to High at Common Mode Error ($V_{DC}$) |
|---|---|
| Channel X, Y, Z | +1.25 |